

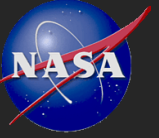


# **Medical Optimization Network for Space Telemedicine Resources (MONSTR)**

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**MONSTR Project Manager**  
**Exploration Medical Capability Element**

**HRP IWS**  
**January 2017**

# Agenda -UPDATE



- The Challenge
- The Need
- The Approach

# The Challenge



## The Setting - Terrestrial



## The Resources





# The Challenge



## The Setting – Earth Reliant



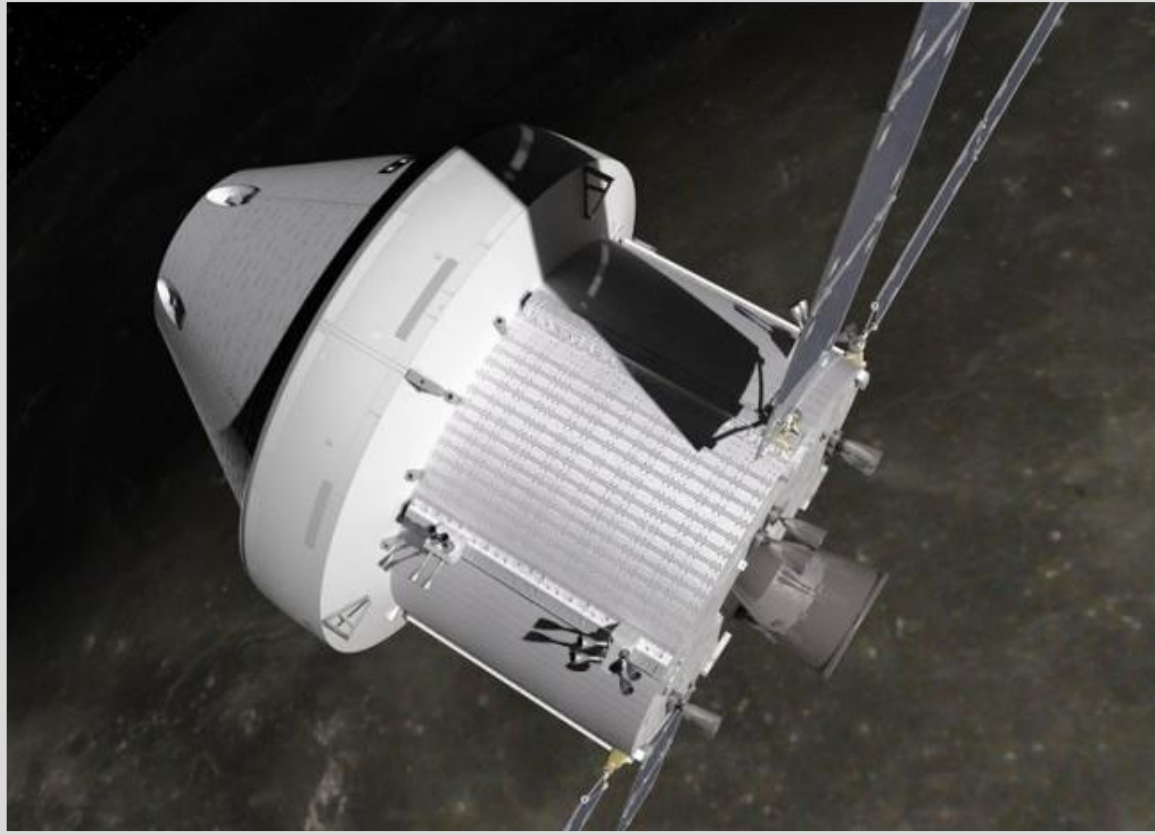
## The Resources



# The Challenge



## The Setting – Proving Ground



## The Resources





# The Challenge



## The Setting – Earth Independent



## The Resources



# The Need



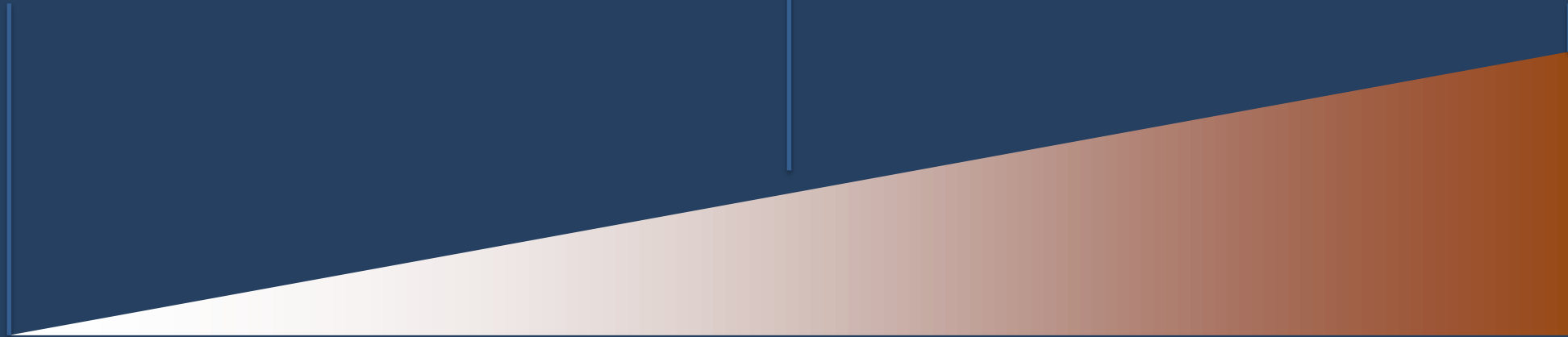
A doctor, a  
stethoscope,  
and a bag of  
medicine

?

A team of  
doctors and  
a multi-bed  
ICU

Simple

Complex



# The Approach



MONSTR

Home

Conditions

Actions

Resources

DRM

Admin ▾

## Medical Optimization Network for Space Telemedicine Resources (MONSTR)

Long-duration missions beyond low Earth orbit introduce new constraints to the space medical system. Beyond the traditional limitations on inflight mass, power, and volume, consideration must be given to other factors such as communication delays, the inability to evacuate to Earth, and limitations in clinical skillsets among the crew. As the medical system for an exploration mission is developed, the ability to evaluate the trade space of medical resources and their relative levels of importance is critical to ensure adequate medical care during these missions.

The Medical Optimization Network for Space Telemedicine Resources (MONSTR) was conceived and designed to aid in the prioritization of medical resource research and development and providing input for quantitative risk analyses.

### Resources

Medical resources are tangible (e.g. durable or consumable medical equipment and, pharmaceuticals) or intangible (e.g. clinical skillsets, computing resources, and software) assets that can be used for providing health care and services to the crew.

### Actions

A set of resources comprise a medical action, which represents a procedure or task (e.g. perform x-ray imaging) to be performed by a caregiver.

### Capabilities

A set of actions comprise a capability, which represents a high level process (e.g. diagnose, treat) to be performed by the caregiver.

### Conditions

The medical conditions included in this tool have been determined by the ExMC physician community. In addition to condition name, this tool contains probabilities of occurrence and definitions of the best case and worst case scenarios of each condition.



# The Approach



## Conditions

The best and worst cases of “probable” medical conditions

## Capabilities

Prevention, diagnosis, treatment, & long-term management

## Actions

The tasks performed within a capability

## Resources

Tangible and intangible assets used to perform an action

Operations

[Back to Condition List](#)

[Add Capability](#)

Criticality Definition

- 0 - Not Needed
- 1 - Nice to Have
- 2 - Desired
- 3 - Mandatory

In-Page Navigation

[Abdominal Injury Details](#)

[Capability to Diagnose Abdominal Injury](#)

[Capability to Long-Term Management Abdominal Injury](#)

[Capability to Treat Abdominal Injury](#)

Abdominal Injury Details

<b>Id</b>	1
<b>Name</b>	Abdominal Injury
<b>Best Case Definition</b>	The best case scenario is defined as a mild or moderate blunt abdominal injury resulting in localized pain/discomfort and/or ecchymosis, with no hollow or solid organ involvement and no evidence of peritonitis or bleeding, requiring only minimal treatment.
<b>Worst Case Definition</b>	The worst case scenario is defined as severe abdominal injury resulting in abdominal cavity injury, which may develop into hemorrhage and/or shock; or a blunt abdominal trauma that causes damage of the internal abdominal organs with secondary complications of shock, peritonitis, and sepsis.

Capability to Diagnose Abdominal Injury

Diagnose

[+ Associate Action](#)

[Edit Capability Details](#)

Search:

Action		BC Crit.	WC Crit.		Resources
Imaging - CT - Abdomen/Pelvis Imaging		1	3		
	<b>Name</b>	<b>Type</b>	<b>BC Crit.</b>	<b>WC Crit.</b>	<b>BC Weighted</b> <b>WC Weighted</b>
	CT Scanner	Equipment	3	3	3 9
	Gurney	Equipment	1	1	1 3
	IV Access - Minor	[action]	2	2	2 6
	IV Contrast	Medication	2	2	2 6
	PO Contrast	Medication	2	2	2 6
	Radiology	Skill	3	3	3 9

[Edit Action Association](#)

Operations

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Abdominal Injury Details

Capability to Diagnose Abdominal Injury

Capability to Long-Term Management Abdominal Injury

Capability to Treat Abdominal Injury

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Condition

Capability to Diagnose Abdominal Injury

Diagnose

+ Associate Action

🔗 Edit Capability Details

Search:

Action	<div>⌵</div> BC Crit. ⌴	<div>⌵</div> WC Crit. ⌴	Resources					
Imaging - CT - Abdomen/Pelvis Imaging	1	3	Name	Type	BC Crit.	WC Crit.	BC Weighted	WC Weighted
			CT Scanner	Equipment	3	3	3	9
			Gurney	Equipment	1	1	1	3
			IV Access - Minor	[action]	2	2	2	6
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Operations

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Capability to Diagnose Abdominal Injury

Capability to Long-Term Management Abdominal Injury

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Action	BC Crit. ⬇️⬆️	WC Crit. ⬆️⬇️	Resources																																										
Imaging - CT - Abdomen/Pelvis Imaging	1	3	<table><thead><tr><th>Name</th><th>Type</th><th>BC Crit.</th><th>WC Crit.</th><th>BC Weighted</th><th>WC Weighted</th></tr></thead><tbody><tr><td>CT Scanner</td><td>Equipment</td><td>3</td><td>3</td><td>3</td><td>9</td></tr><tr><td>Gurney</td><td>Equipment</td><td>1</td><td>1</td><td>1</td><td>3</td></tr><tr><td>IV Access - Minor</td><td>[action]</td><td>2</td><td>2</td><td>2</td><td>6</td></tr><tr><td>IV Contrast</td><td>Medication</td><td>2</td><td>2</td><td>2</td><td>6</td></tr><tr><td>PO Contrast</td><td>Medication</td><td>2</td><td>2</td><td>2</td><td>6</td></tr><tr><td>Radiology</td><td>Skill</td><td>3</td><td>3</td><td>3</td><td>9</td></tr></tbody></table>	Name	Type	BC Crit.	WC Crit.	BC Weighted	WC Weighted	CT Scanner	Equipment	3	3	3	9	Gurney	Equipment	1	1	1	3	IV Access - Minor	[action]	2	2	2	6	IV Contrast	Medication	2	2	2	6	PO Contrast	Medication	2	2	2	6	Radiology	Skill	3	3	3	9
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Capability to Long-Term Management Abdominal Injury

Capability to Abdominal Imaging

Abdominal Injury Details

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Condition

Capability

Capability to Diagnose Abdominal Injury

Diagnose

+ Associate Action

🔗 Edit Capability Details

Search:

Action	BC Crit. ⬇️⬆️	WC Crit. ⬆️⬇️	Resources
Imaging - CT - Abdomen/Pelvis Imaging	1	3	

🔗 Edit Action Association

Name	Type	BC Crit.	WC Crit.	BC Weighted	WC Weighted
CT Scanner	Equipment	3	3	3	9
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Capability to Long-Term Management Abdominal Injury

Cap...

Abd...

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Condition

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Capability to Diagnose Abdominal Injury

Diagnose

+ Associate Action

🔗 Edit Capability Details

Search:

Action

Imaging - CT - Abdomen/Pelvis Imaging

Action	BC Crit. ⬇️⬆️	WC Crit. ⬆️⬇️	Resources
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Imaging - CT - Abdomen/Pelvis Imaging	1	3	
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🔗 Edit Action Association

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Resources



## Operations

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## In-Page Navigation

[Abdominal Injury Details](#)

[Capability to Diagnose Abdominal Injury](#)

[Capability to Long-Term Management Abdominal Injury](#)

[Capability to Treat Abdominal Injury](#)

## Abdominal Injury Details

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## Capability to Diagnose Abdominal Injury

Diagnose

[+ Associate Action](#)

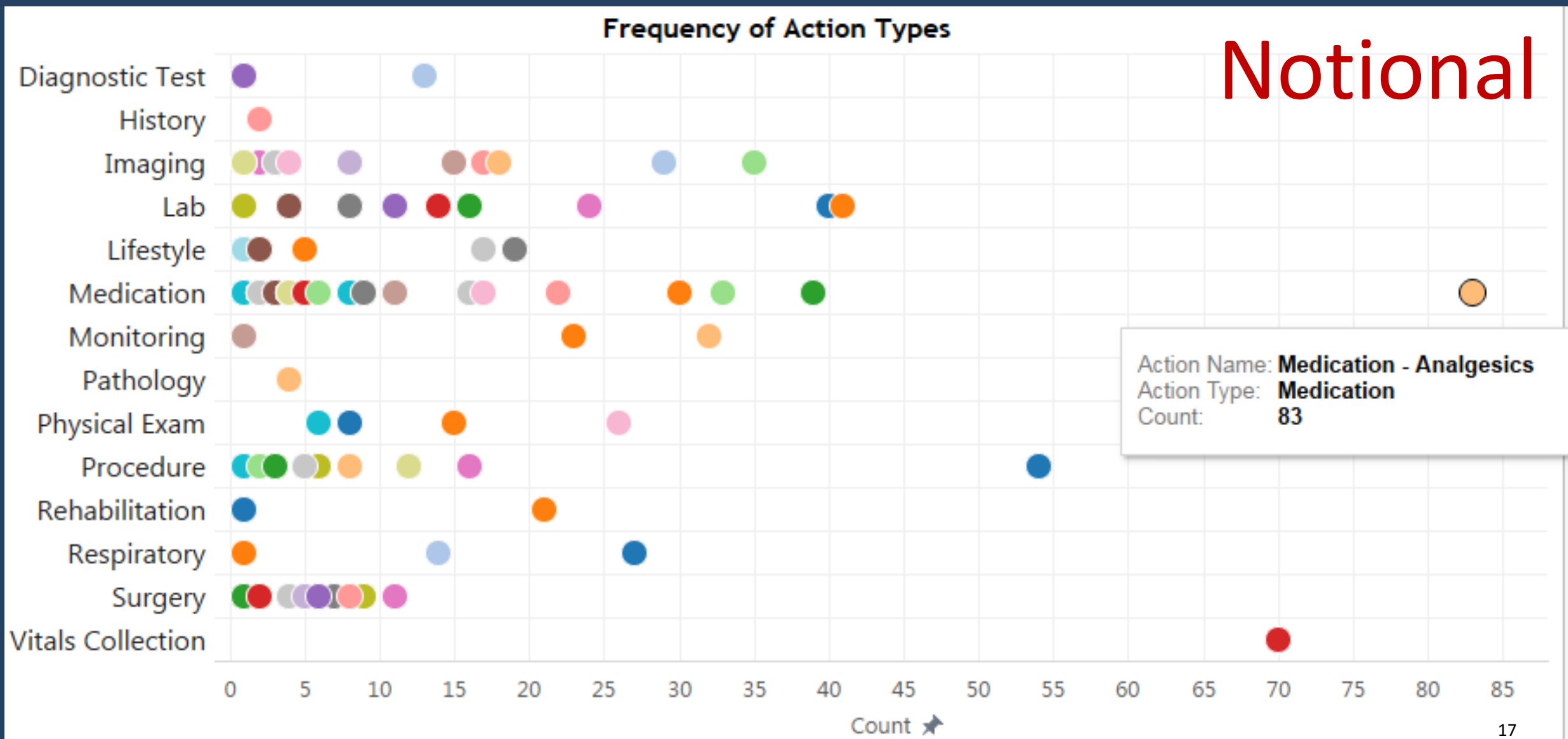
[Edit Capability Details](#)

Search:

Action	BC Crit.  WC Crit. 		Criticalities			
	BC Crit.	WC Crit.	BC Crit.	WC Crit.	BC Weighted	WC Weighted
Imaging - CT - Abdomen/Pelvis Imaging	1	3				
<a href="#">Edit Action Association</a>						
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Abdominal Injury	Chest Injury	Headache (Space Adaptation)	Retinal Detachment
Abdominal Wall Hernia	Choking/Obstructed Airway	Hearing Loss	Seizures
Abnormal Uterine Bleeding	Constipation (Space Adaptation)	Hemorrhoids	Sepsis
Acute Angle-Closure Glaucoma	Decompression Sickness Secondary to Extr	Herpes Zoster Reactivation (shingles)	Shoulder Dislocation
Acute Arthritis	Dental: Abscess	Hip Sprain/Strain	Shoulder Sprain/Strain
Acute Cholecystitis/Biliary Colic	Dental: Avulsion (Tooth Loss)	Hip/Proximal Femur Fracture	Skin Abrasion
Acute Compartment Syndrome	Dental: Caries	Hypertension	Skin Infection
Acute Diverticulitis	Dental: Crown Loss	Indigestion	Skin Laceration
Acute Pancreatitis	Dental: Exposed Pulp	Influenza	Skin Rash
Acute Prostatitis	Dental: Filling Loss	Insomnia (Space Adaptation)	Sleep Disorder
Acute Radiation Syndrome	Depression	Knee Sprain/Strain	Small Bowel Obstruction
Acute Sinusitis	Diarrhea	Lower Extremity (LE) Stress Fracture	Smoke Inhalation
Allergic Reaction (mild to moderate)	Elbow Dislocation	Lumbar Spine Fracture	Space Motion Sickness (Space Adaptation)
Altitude Sickness	Elbow Sprain/Strain	Medication Overdose/Adverse Reaction	Stroke (cerebrovascular accident)
Anaphylaxis	Eye Chemical Burn	Mouth Ulcer	Sudden Cardiac Arrest
Angina/Myocardial Infarction	Eye Corneal Ulcer	Nasal Congestion (Space Adaptation)	Toxic Exposure: Ammonia
Ankle Sprain/Strain	Eye Infection	Neck Sprain/Strain	Traumatic Hypovolemic Shock
Anxiety	Eye Irritation/Abrasion	Nephrolithiasis	Urinary Incontinence (Space Adaptation)
Appendicitis	Eye Penetration (foreign body)	Neurogenic Shock	Urinary Retention (Space Adaptation)
Back Pain (Space Adaptation)	Finger Dislocation	Nose Bleed (Space Adaptation)	Urinary Tract Infection
Back Sprain/Strain	Fingernail Delamination Secondary to Extra	Otitis Externa	Vaginal Yeast Infection
Barotrauma (ear/sinus block)	Gastroenteritis	Otitis Media	Visual Impairment and/or Increased Intracra..
Behavioral Emergency	Head Injury	Paresthesias Secondary to Extravehicular A..	Wrist Fracture
Burns secondary to Fire	Headache (CO2 induced)	Pharyngitis	Wrist Sprain/Strain
Cardiogenic Shock secondary to Myocardial Inf	Headache (Late)	Respiratory Infection	

# MONSTR Output

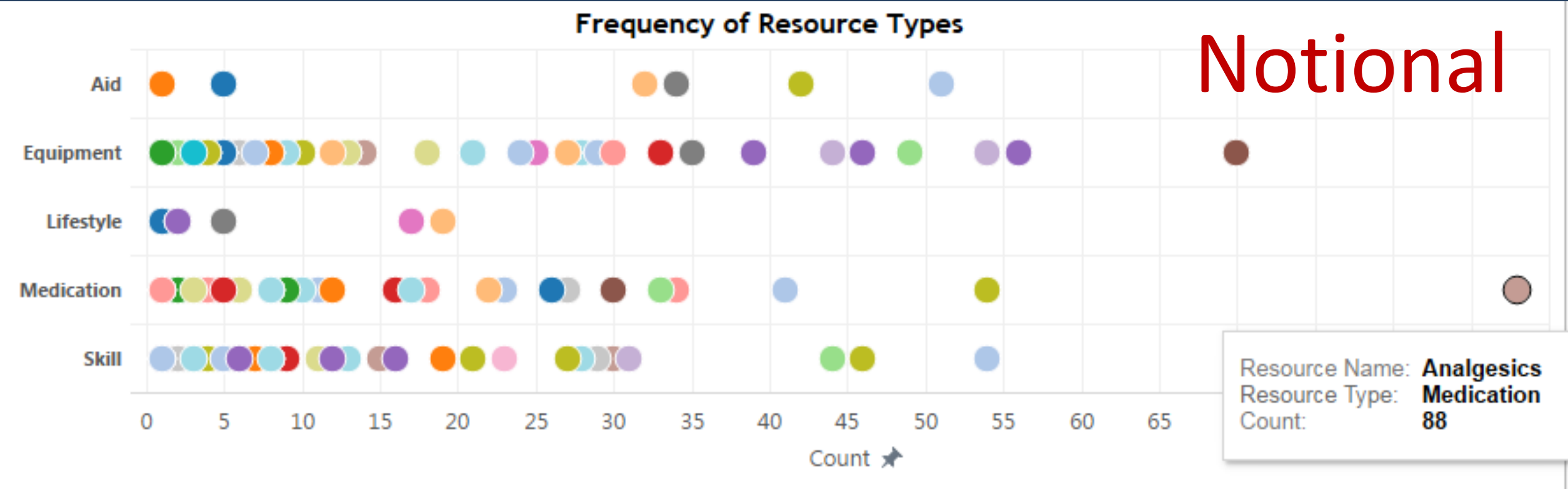




# MONSTR Output



Notional



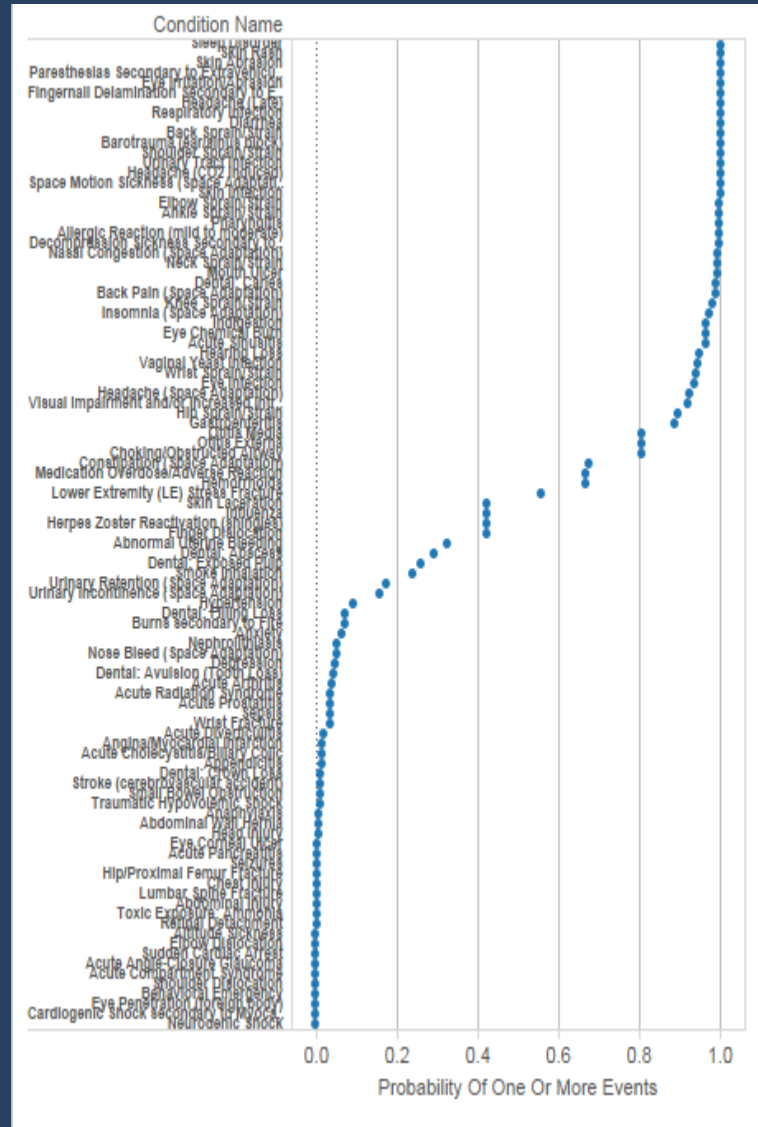
# Applying MONSTR



## Weighted Criticality

Function of:

- $\text{Criticality}_{\text{Resource}}$
- $\text{Criticality}_{\text{Action}}$
- $\text{Frequency}_{\text{Resource}}$

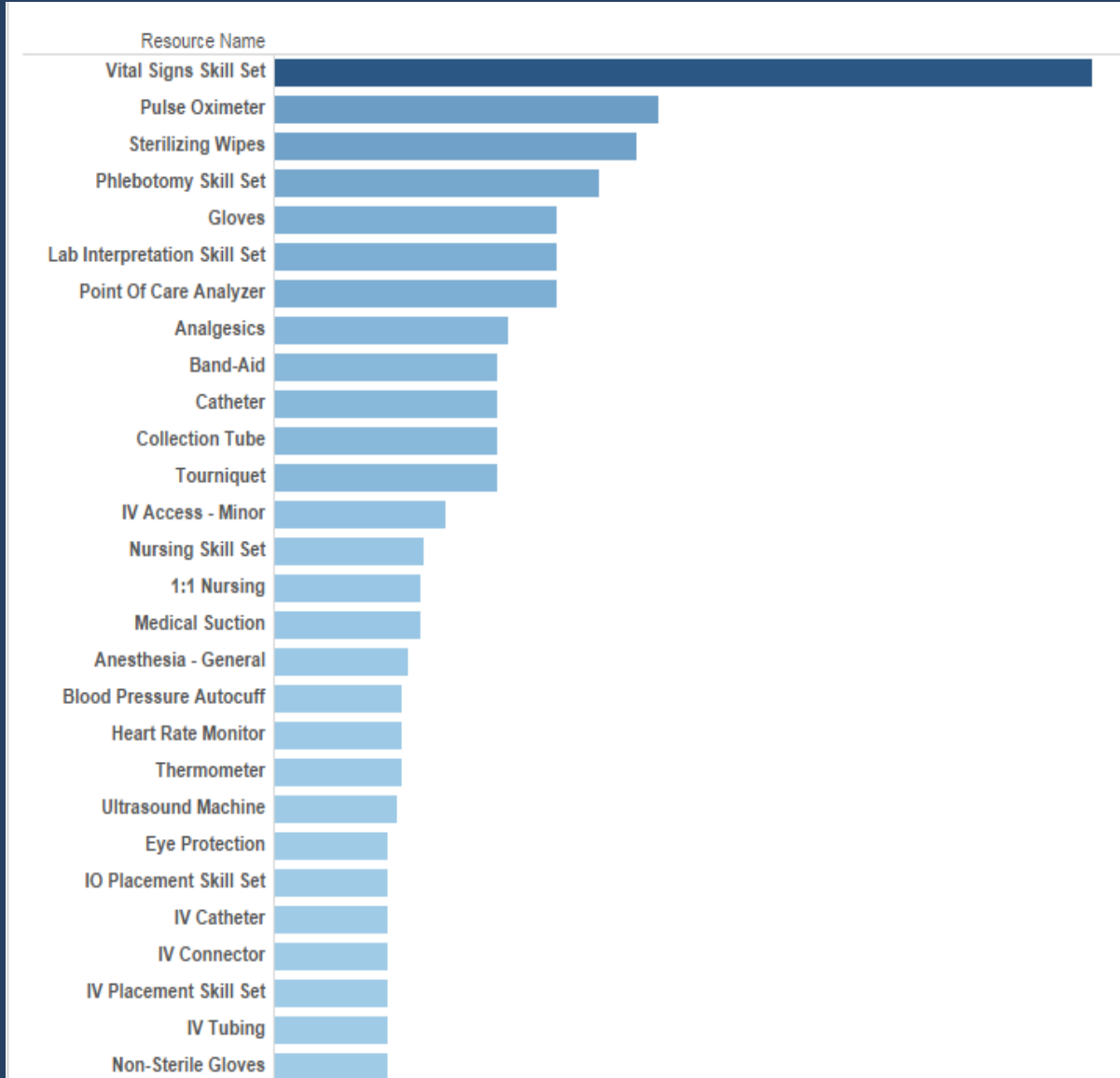


## Mission Criticality

Function of:

- $\text{Weighted Criticality}$
- $\text{Probability}_{\text{Condition}}$

# Applying MONSTR



Given other resource metrics:

- Mass/volume/power
- Training requirements
- Etc.

Which resources:

- Are flight ready now?
- Require ExMC investment?
- Will be developed by industry?
- Require alternatives?



# MONSTR Value



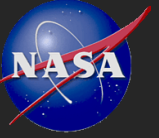
## MONSTR provides:

- Investment prioritization to maximize capabilities
- Objective, quantified measures to support system trades
- Repeatable decision making processes

## MONSTR is not:

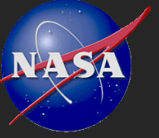
- A definitive answer to what medical resources are required for any DRM

# Forward Plan



- Continued data population via ExMC Physicians
- Integration into ExMC Systems Engineering system model
  - SysML
- Review and modification of “weighted” scoring scheme
- Additional database and GUI development
- Data validation (potentially via crowd sourcing)
- Data analysis and reporting
- Use of MONSTR data to support trade study analysis

# Acknowledgements



Thanks goes to:

## MONSTR Leadership

Dr. Eric Antonsen

Dr. Ronak Shah

Jeff Reilly

Kerry McGuire

## MONSTR Project Team

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Kim Council

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